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Penetrating radiation impact on NIF final optic components

Christopher D. Marshall, Joel A. Speth, and Stephen A. Payne

Lawrence Livermore National Laboratory
P. O. Box 808, L-441, Livermore, CA 94550
510-422-9781, cmarshall@llnl.gov

Thermonuclear ignition on the National Ignition Facility (NIF) will produce a significant quantity of radiation in the target area. For the case of a 20 MJ yield scenario, NIF will produce $\sim 10^{19}$ neutrons with a characteristic DT fusion 14 MeV energy per neutron. There will also be a substantial amount of *x*-rays, gamma rays, and secondary neutrons, as well as solid, liquid and gaseous target debris produced either directly or indirectly by the inertial confinement fusion process. A critical design issue is the protection of the final optical components as well as sophisticated target diagnostics in such a harsh environment. This presentation will discuss the impact that neutrons and gamma rays, which will penetrate through the debris shield, will have on the "permanent" final optical components, namely the KDP frequency converters and silica final focus lenses.

We have performed a variety of neutron and gamma irradiation experiments in the SNL SPR-III, LANL LANSCE, CEA Sommes, and LLNL's ^{60}Co, and LINAC. These provide complementary sources of γ-rays and neutrons with various energy and pulse formats. From the experiments and modeling performed to date, fused silica is expected to have <1% loss at 3ω in the final focus lens after 30 years of use at baseline NIF DT fusion yield levels. This optical absorption is due both to neutron induced displacements and γ-ray induced color center formation. If fused quartz is utilized, 1% loss levels are typically reached within 1 year for CDR level fusion yields. Therefore it is advisable that only radiation resistant synthetic fused silica should be utilized for the final focus lenses.

Experiments performed on KDP indicate that neutron collisions do not appear to degrade the optical properties of KDP at NIF relevant fluences and (2) γ-rays can cause significant problems if impurities such as As are present at ppm levels. For As, which appears to be a common impurity, we have been able to construct a physical picture and measure quantitative parameters necessary to model the radiation-induced losses expected for KDP and KD*P. We also found that other impurities such as Al, Fe, As, Cr, Pb, and V can also cause significant problems at ppm level concentrations. Assuming these impurities are brought to acceptable levels, the neutron and gamma ray damage to the KDP arrays will not present a significant problem for the 30-year operation on NIF. In fact the more pure growths of KDP at LLNL showed virtually no observable degradation (<1%/cm losses) at up to the equivalent dose of up to ~100 NIF years, using the LANSCE facility at LANL (which has a more severe radiation environment than that expected on NIF).

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